Market design for a high-renewables European electricity system

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Overview of this talk

1. EU climate targets: Implications for electricity
2. Market impacts of RES-E to date
3. Principles for a “2nd generation” market design
4. Key elements of market design
5. Summary of policy recommendations
EU climate targets: Implications for electricity

Electricity will bear large fraction of EU 2030 climate targets
  — Key role for intermittent renewable generation
  — Resistance to nuclear, limited hydro expansion, environmentally-undesirable coal
  — Dominant 50%+ RES-E share needed in many MSs

Large challenge without new electricity market design
  — Current generation investment driven by governments: RES support & capacity mechanisms
  — Future opportunities from RES cost reductions, battery technologies, further interconnection etc.

Today: Ideas for “2nd generation” market design
Swanson’s law & German electricity prices

Solar PV cost ↓20% as capacity x2

Wholesale price ↓50% in 5 years

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Key market impacts of RES to date

1. Cost reductions
   — Learning rates: Solar PV 17-22% & wind 7-9%

2. Merit-order effect
   — *Short run*: Lower prices, sometimes negative…
     — Germany: ≈40% of 2011-16 price decline due to RES
   — *Longer run*: Exacerbates “missing money” problem & reduces forward market liquidity
     — Italy: More wholesale market power in evening hours

3. System issues
   — Higher transmission costs due to locational distortions
   — Fewer conventional plant to provide ancillary services

*Plus*: Many impacts were not anticipated by policy & firms…
Recent auction results for renewables

DENMARK
600 MW Offshore Wind at 53.9 USD/MWh

KINGDOM OF THE NETHERLANDS
700 MW Offshore wind at -80.4 USD/MWh

GERMANY
128 MW Solar at -84 USD/MWh (4th tender)
130 MW Solar at -81 USD/MWh (5th tender)

RUSSIAN FEDERATION
610 MW Wind

CHINA
1000 MW Solar at 78 USD/MWh

MOROCCO
850 MW Wind at -30 USD/MWh

UAE
800 MW Solar at 29.9 USD/MWh (Dubai Auction)
350 MW Solar at 24.2 USD/MWh (Abu Dhabi Auction)

INDIA
6500 MW Solar at -73 USD/MWh

ZAMBIA
73 MW Solar at -67 USD/MWh

Countries that have awarded renewable energy in auctions in 2016

Note: a) GWh: gigawatt-hour.
Source: Countries that have implemented auctions to date based on REN21, 2010, 2011, 2012, 2013, 2014 and 2015; and recent bids from IRENA, 2017a

Source: IRENA (2017)
Principles for “2nd generation” market design

1. Correct market failures close to source
2. Allow cross-country variation, not one-size-fits-all
3. Let prices reflect value & cost of all electricity services
4. Collect revenue shortfalls with least distortion
5. De-risk financing of low-carbon investment
6. Retain flexibility to respond to new information
Further interconnection & market integration

Intermittent RES raises the value of interconnection
1. Reduces supply variability
2. Dampens price volatility

Table 1: Potential short-run gains from EU-wide market integration

<table>
<thead>
<tr>
<th></th>
<th>EU-28 estimate</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>€ million</td>
</tr>
<tr>
<td>Day-ahead coupling</td>
<td>1,010</td>
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<tr>
<td>Intraday coupling</td>
<td>37</td>
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<tr>
<td>Balancing</td>
<td>1,343</td>
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<tr>
<td>Unscheduled flows</td>
<td>1,360</td>
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<tr>
<td>Curtailment</td>
<td>130</td>
</tr>
<tr>
<td>Total gains</td>
<td>3,880</td>
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</tbody>
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Large overall EU-wide gains from more market integration
— Remunerate properly all interconnector services
— Connect more to hydro reserves in Nordic market

Challenge: Uneven distribution of benefits across MSs
Realism on electric energy storage

Do batteries “solve” intermittent RES? Not any time soon…

1. Volumes remain tiny vs other types of storage
2. Optimistic forecasts still imply high running costs
   — Moore’s Law does not apply to electrical storage
3. Challenges around incentives & business models

⇒ Other flexibility mechanisms cheaper & more important
   (e.g., interconnectors, flexible gas-fired plant, DSR)

High-value uses for battery storage:

1. Provide very fast frequency response…
   (remuneration?)
2. Shave peak use & defer network upgrades…
   (incentives?)
Electric storage vs pumped storage hydro

Pumped storage hydro

Flywheels 931 MW
Compressed Air Energy Storage (CAES) 637 MW
Sodium Sulphur 189 MW
Advanced lead-acid/lead acid 109 MW
Capacitor 76 MW
Redox flow battery 42 MW
Nickel-cadmium 30 MW
Others 34 MW
Lithium-ion 952 MW

Less than 1% of PSH

Note: Pumped storage data are for 2016; other data are for 2014.
Source: IRENA, 2015h; pumped storage data from IHA, 2016
Source: IRENA (2017)
EU’s current preferred policy instrument: Premium FiTs
— 2013: 58% FITs, 26% green certificates, 16% PFiTs

Why support RES? To correct market failures…
1. Innovation spillovers
   — Cost reductions driven by volume of installed capacity
2. Financing constraints
   — High-RES-E system more sensitive to cost of capital
3. Carbon underpricing

⇒ Use auction-determined support for capacity (not output)
   — Targets directly innovation market failure
   — Auctions play two roles:
     1. Minimize overall procurement costs
     2. Reveal cost information across technologies
Auction design to support RES capacity

Pay for a fixed number of MWh/MW capacity:

- FiT of €X per MWh for the first Y full-load hours of output
  - €X determined at auction
  - Y set by government (by technology & location)
    - e.g. Y=30,000 hrs & 34% capacity factor → 10 year PPA
- Thereafter RES receives wholesale market price (only)

⇒ Capital subsidy: lifetime support is independent of output at any given hour

1. Creates predictable post-auction payment stream
2. Reduces locational distortions for new investment
   - Reduces transmission costs
3. Avoids incentive to bid negative prices to earn subsidy

Similar design has been used for onshore wind in China
More granular electricity pricing

Current short-run pricing does not properly value flexibility

1. **Demand**: Intermittent RES-E raises need for granular prices
2. **Supply**: Costs of sending differentiated price signals is falling

Benefits of nodal pricing
   — Better locational incentives for new generation investment
   — Complement to support for RES *capacity*
   — Better network use, interconnector arbitrage & storage use

How granular prices?
   — **Nodal**: more efficient dispatch (√ if very congested)
   — **Zonal**: more liquidity (√ if less congested)

Transition management?
   — Hedging more volatile prices (e.g. TCCs in US)
   — Grandfathering of FTRs?
Long-term contracts & risk management

Volatile climate policy creates new policy/regulatory risks
- RES subsidies; EU ETS reforms; carbon price floor
- Plethora of policies favours private sector “policy arbitrage”

⇒ Overarching goal: Simplify & stabilize policy environment
- Better remuneration of flexibility services
- Less reliance on politically-backed projects

Capacity mechanisms can correct “missing markets”
- Reliability Options (ROs) allow scarcity prices & signal efficient use of interconnector capacity

Risk management for market-driven RES
1. Balancing risk
2. Wholesale price risk           Hedging (e.g., via large utility)
3. Output risk
Summary of policy recommendations

① Use **capacity-based auctions** for RES support

② Ensure **proper remuneration of interconnectors**

③ Shift to **more granular pricing** of electricity

④ Support **market-based long-term contracting**

⑤ Be realistic about medium-run **potential of battery storage**

⑥ Create more **cost-reflective DG network charges**

**Plus:** Shift from RES deployment support to early-stage R&D